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Theater Missile Defense:

A Primer for the Uninitiated

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A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not endorsed by the Naval War College or the Department of the Navy.

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Theater Missile Defense (TMD) is a much discussed topic among operation and strategic planners. Some believe that TMD is an urgent and present necessity. Others believe that the threat has not fully developed and that time remains to develop weapon systems that can better counter the threat.

The purpose of this paper is to provide a TMD primer to explain the fundamentals of TMD, the various Service approaches, and to provide operational and strategic thinkers and planners a clear view of TMD, its inherent problems and solutions. Broad areas of TMD are currently under addressed. Although a great deal of discussion, development , and funding has gone into TMD, there is no concise Joint approach. Active defense remains a controversial issue sought after by Service headquarters and contractors. Attack operations is considered a collateral mission. Passive defense is severely under addressed. C4I is proceeding for early warning to TMD weapon systems, but fire control and distribution systems remain in the early stages of development.

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ABSTRACT

Theater Missile Defense (TMD) is much discussed topic among operational and strategic planners. Some believe that TDM is an urgent and present necessity. Others believe that the threat has not fully developed and that time remains to develop weapons systems that can better counter the threat.

TMD remains a greatly misunderstood issue. TMD advocates tend to support one particular weapons system or service approach over others for a variety of reasons. Clouding the issue is the potential for incredible funding. Since 1991, more than $16 billion has been spent on TMD development. In a decreasing military force with ever decreasing budgets, TMD is one of the few growth industries.

The purpose of this paper is to provide a basic TMD primer, to explain the fundamentals of TDM, the various Service approaches, and to provide operational thinkers and planners a clear view of TMD and its inherent problems and solutions. Broad areas of TMD are currently under addressed. Although a great deal of discussion, development, and funds have gone into TMD since 1991, there is no concise Joint approach. Active defense remains a controversial issue sought after by Service headquarters and contractors. Attack operations is considered a collateral mission. Passive defense is severely under addressed. C4I is proceeding for early warning to TMD weapon systems, but fire control and distribution systems are in the early stages of development.

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TMD remains a greatly misunderstood issue. TMD advocates tend to support one particular weapons system or Service approach over others. Clouding the issue is the potential for incredible funding. Since 1991, more than $16 billion has been spent on TMD development. In a decreasing military force with ever decreasing budgets, TMD is one of the few growth industries.

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Theater Ballistic Missiles - A 20th Century Weapon

On 18 January, 1991, Saddam Hussein fired a Scud missile against US forces. Patriot batteries made history that night, when Alpha Battery, 2-7 ADA, protecting forces in Dhahran, Saudi Arabia, recorded the first intercept of a tactical ballistic missile (TBM) in combat. Scud debris that fell to the ground from the TBM, the missile would have struck a village housing soldiers from VII Corps. Scud intercepts became a nightly event. By the end of the war, Saddam had fired 88 missiles, 42 against Israel and 46 against Saudi Arabia. Of the 88 Scuds fired, 7 failed in flight, 17 fell harmlessly in the open desert or in the sea. In Saudi Arabia Scuds were mainly fired at civilian targets in Ryhiad and Dhahran. 34 of 36 Scuds were `successfully' engaged by Patriot batteries. One fell into the harbor in Jubail, but did not explode. The other impacted on a

barracks in Dhahran, killing 28 servicemen and wounding almost 100 others. In Israel, 11 missiles were fired at the start of the war. All impacted in Israeli cities, causing over 100 deaths and injuries. After US and Dutch Patriot batteries were deployed, all of the next 17 Scuds were engaged. Politically, the deployment of Patriot batteries kept Israel from intervening in the war, and providing a visible sign of US resolve to protect Israel. Thousands of aircraft sorties were diverted from military targets to search for missile launchers, but not a single launcher was confirmed as destroyed by aircraft.

This conflict identified many deficiencies in US military forces and raised many questions. Although not a single injury was reported from falling debris, some were concerned that Scud debris might injure friendly forces and civilians,. The 28 American Service men who died in the Scud attack in Dhahran are in sharp contrast to the missile casulaties of the Iran-Iraq War where Baghdad's Scuds caused over 1100 dead and 4000 wounded. Others raised concerns that future missile attacks could include chemical or nuclear warheads that, if destroyed over friendly forces, would cause injuries. Clearly, there was much work to be done.

Many saw this as a new era in warfare with sophisticated weapons directed against civilian populations. Although certainly a 20th Century phenomenon, missile attacks did not begin with this conflict. On 13 June 1944, Nazi Germany launched a V-1 missile against Swanscombe England. Between 8 September 1944 and 27 March 1945, the Germans fired some 1,115 V-2s at Britain and 1,982 more missiles were fired at targets in liberated north western Europe. Political necessity forced the leaders to divert military forces from other priorities to solve the tactical missile problem.[1] "The fighter and anti-aircraft gun defenses assembled to counter successfully the low flying V-1 cruise missiles that had been attacking London since June 1944 could not defend it against the supersonic V-2.

> General Eisenhower diverted 30% of allied bomber sorties away from targets inside Germany to attack V-1 launch sites. He did this while the battle for Normandy was still raging."[2]

In 1973, Egyptian and Syrian troops attempted, unsuccessfully, to fire several Scud and FROG missiles at Israeli troop concentrations. In 1986, Libya launched two

Scud missiles, without effect, at a US LORAN facility on an Italian island off the coast of Sicily.[3]

From 1980 -1988, Iran and Iraq exchanged over 600 Scud B and modified Scud C missiles. During one six month period during the Iran-Iraq war between 1987 and 1988, Iraq rained down missiles on Tehran, killing 2,000 Iranians and driving half the population form the city.[4] On 27 October 1982, a single Scud B exploded in the city of Dezful, Iran, killing 21 civilians and wounding more than 100 others.[5] Despite the Scud's small warhead, strikes on Tehran were credited with causing panic and contributed to a decline in Iranian civilian morale that aided greatly in bringing Iran to the negotiating table.[6]

Between 1988 and 1991, the Soviet sponsored government in Afghanistan fired Scud B's against Mujahideen rebels killing many. As recent as 1994, Yemen exchanged Scud missiles between Aden and Sana.

Ballistic missile attacks are becoming a more frequent part of warfare in the 20th Century. Their value as political weapons greatly exceeds their current value as military weapons. As technology prolifereates and range, accuracy, and payload increase, the usefulness of ballistic missiles on the battlefield is likely to expand well into the 21st century. Unfortunately, defenses against missile attacks are still at an early stage. Many areas remain under addressed as the US military Services, supported by various contractors, compete for reducing defense dollars.

Understanding Theater Missile Threats

An enemy in a developed theater may employ theater missiles to initiate attacks against a variety of targets, such as air defense artillery sites, command and control elements, communications nodes, air facilities, seaports, logistic centers, key civilian facilities, nuclear delivery systems, storage sites, naval vessels, population centers and industrial centers.[7]

Ballistic missiles are appealing for developing nations and often serve as a status symbol. Their long range, short flight time, relative low cost and the ability to carry a variety of warheads provide unique political as well as military advantages. In addition, defenses against ballistic missiles are not as mature or widely deployed as defenses against aircraft of other weapon systems.[8] Missile-equipped nations may not need to use a large number of missiles to cause dramatic political changes in a region. The threat or subsequent use of even a few weapons may be enough to achieve a regional goal.[9]

Ballistic missiles offer potential users several advantages over manned aircraft.[10] Modern, technologically sophisticated aircraft require considerable maintenance, an extensive support structure, expensive ordinance, a well maintained runway and continuing, costly training. Ballistic missiles are relatively inexpensive, and require no elaborate support structure or training to operate. Their ease of use and low cost make ballistic missiles especially desirable for developing countries. Perhaps of most importance, the absence of any viable defense against ballistic missiles offers a free ride to their targets. Salvo attacks can maximize damage and compensate for the inaccuracy of older technological missiles.[11] The proliferation of ballistic missiles continues to be a major concern.

Ballistic missiles are typically classified by range. Short range ballistic missiles (SRBMs) are fired at distances less than 300 kilometers from their intended target. Intermediate range ballistic missiles are generally figured to be ranges between 300 and 900 kilometers from their target. Long range ballistic missiles are generally considered as having ranges greater than 900 kilometers. Strategic (intercontinental) missiles are considered to have ranges greater than 10,000 kilometers. Over a dozen families of theater ballistic missiles are currently available to developed and developing nations.[12] (Manufacturing nations are highlighted)

Missile Ranges 300 Kilometers or Less

Operational	Range (Km)	Payload (Kg)	Countries
Hatf I	80	500	**Pakistan**
Chin Feng	100	275	Taiwan
SS-21	120	450	**Russia**, Belarus, Czech, Hungary, Kazakstan, Libya, North Korea, Poland, Serbia, Slovakia, Syria, Ukraine
Mushak-120/160	120/160	500/unk	Yemen, Iran
Lance	130	275	Israel
Prithri 1	150	1,000	**India**
Prithri 2	250	500	**India**
NHK-1	180	500	**South Korea**
SSM-1A	150	unk	**Japan**
8610	300	500	**Iran**
Scud-B	300	1,000	**Russia,** Afghanistan, Azerbaijan, Belarus, Bulgaria, Egypt, Georgia, Hungary, Iran, Iraq, Kazakstan, North Korea, Libya, Poland, Romania, Slovakia, Syria, Ukraine, UAE, Vietnam, Yemen,
M-11	300		**China**, Pakistan, Iran
SS-300	300		**Brazil**

Under Development	Range (Km)	Payload (Kg)	Countries
Laith (tested)	90	500	**Iraq**
Alacran	200	500	**Argentina**
Mushak 200	200	500	**Iran**
NHK-2 (tested)	260	450	North Korea
Hatf II (tested)	300	500	**Pakistan**
SS-21C	320	185	**Russia**

Table 2-1

Short range theater missiles normally have a flight time (launch to impact) between 2 and 4 minutes and attain a maximum speed in the terminal phase between .9 meters/second (mach 2.7) to 1.5 meters/second (mach 4.5).[13]

Missile Ranges between 300 and 900 Kilometers

Operational	Range (Km)	Payload (Kg)	Countries
Scud-C	500	700	**Russia,** Iran, North Korea, Syria, Libya
Al Hussein	600	500	Iraq
Jericho I	650	500	**Israel**
M-9	500-650		**China**, Syria, Libya
MB/EE-600	600		**Brazil**

Under Development	Range (Km)	Payload (Kg)	Countries
Hatf III	600	<1,000	Pakistan
Scud-100	600	500	Egypt
Al Fateh	<950	500	Libya
Iran 700	700	500	Iran

Table 2-2

Intermediate range theater missiles normally have a flight time (launch to impact) between 5 and 8 minutes and attain a maximum speed in the terminal phase between 2.2 meters/second (mach 6.5) to 2.5 meters/second (mach 7.5). [14]

Missile Ranges greater than 900 Kilometers

Operational	Range (Km)	Payload (Kg)	Countries
Jericho II	1,500	500	**Israel**
CSS-2	2,700	2,200	Saudi Arabia
			China
			Brazil
MB/EE 1000	1,000		**China**
CSS-5	1,800	600	**France**
S-3	3,000	1,000	

Under Development	Range (Km)	Payload (Kg)	Countries
Tondar-68	1,000	500	**Iran**
No Dong-1 (tested)	1,000	1,000	**North Korea**
No Dong-2	<2,000	<1,000	**North Korea**
Agni (tested)	2,500	1,000	**India**
Taepo Dong-1	>1,000	1,000	**North Korea**
Taepo Dong-2	2,000 - 3,500	unknown	**North Korea**
Sky Horse	950	500	**Taiwan**
DF-25	1,700	2,000	**China**, Iran

Table 2-3

Longer range theater missiles normally have a flight time (launch to impact) greater than 10 minutes and can attain a maximum speed in the terminal phase in excess of 4.6 meters/second (mach 13).[15]

The potential for coercion is perhaps the long-range ballistic missile's greatest value and the greatest challenge to those seeking to deter a state. From the perspective of the leader of a belligerent state, ballistic missiles are an effective instrument -- even a weapon of choice -- to threaten the rear of US and coalition forces

in the face of US air superiority. Missiles with low profile infrastructure and mobile launchers are much less vulnerable to US offensive operations[16] Missiles can have strategic psychological impacts when used against urban areas. Despite efforts to limit proliferation, ballistic missile are expanding in the inventories of armed forces throughout the world.

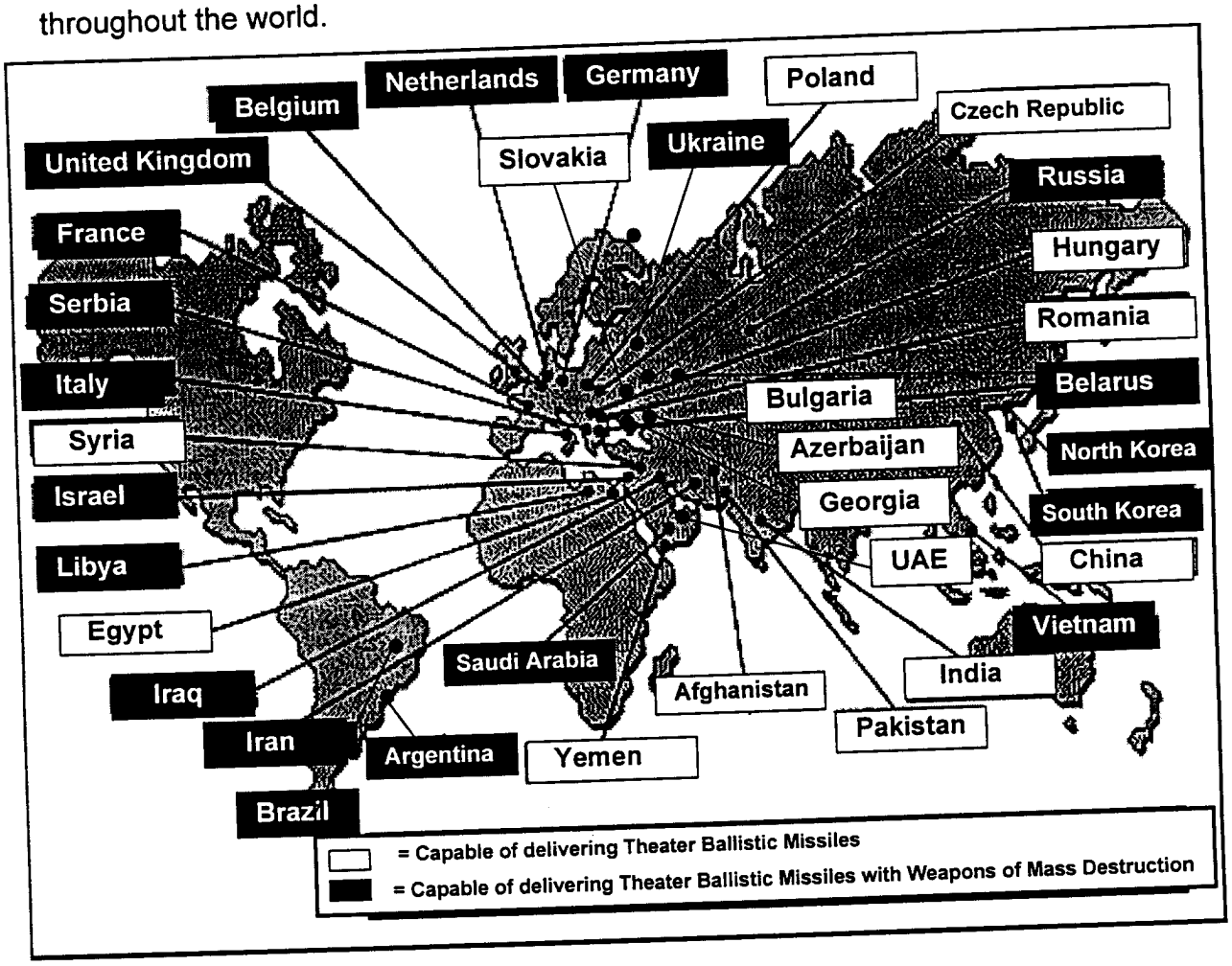

Figure 1 Nations Possessing Tactical Missiles

Joint Doctrine for Theater Missile Defense

Theater Missile Defense (TMD) is inherently a joint mission. Therefore, Joint Force components, supporting combatant commanders, and multinational force TMD capabilities must be integrated toward the common objective of neutralizing or destroying the enemy's tactical missile capability.[17]

The mission of TMD is to protect U.S. Forces, allies and other countries, including vital interests of the U.S. from missile attacks.[18] The advantages for the Joint Force Commander (JFC) are clear. First, TM defenses can help protect US Forces and allow them to function effectively against an adversary armed with advanced ballistic missiles. Second, by protecting cities, advanced defenses can counter the effectiveness of ballistic missiles used as political weapons. Third, allied nations may be more willing to accept U.S. forces on their soil if they know that US Forces are able to protect their cities from ballistic missile attacks.[19]

There are no established procedures or command relationships for TMD. The JFC must establish TMD guidance, objectives, and priorities. Normally, he will assign overall responsibility for air defense, to include TMD, to an Area Air Defense Commander (AADC). Overall TMD responsibility is not clearly defined in joint doctrine, but is evolving toward another duty for the Joint Force Air Component Commander (JFACC).

To understand how to address the TM threat, it is necessary to understand some dynamics of missiles themselves. Launching a ballistic missile is like throwing a basketball. Strong arms, like a rocket motor, **boost** the basketball into the air. Once the ball leaves the arm, (or the rocket motor stops burning) the ball follows a predictable parabolic **mid-course**, subject only to gravity and air resistance. As any basketball player knows, the maximum range of any toss is the result of angle and arm strength. If the correct amount of boost, with the correct angle is applied, then the basketball will sail through the net -- swish -- in the **terminal phase** - - on target. So too with a ballistic missile. Launch angles differ from 45° for intercontinental missiles, to as little as 25° for shorter range missiles.[20]

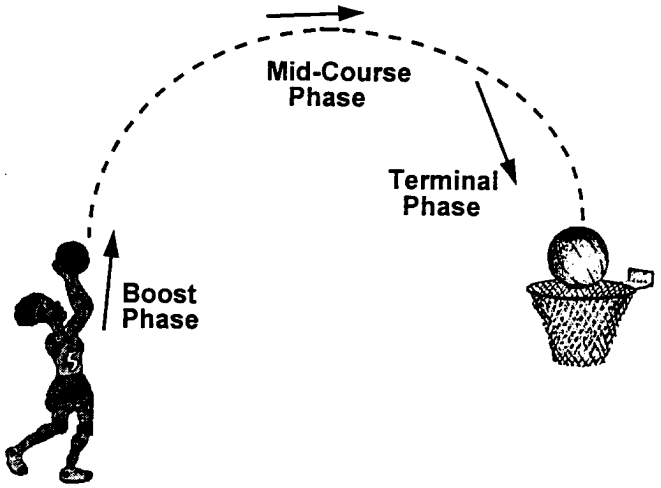

Figure 2 Ballistic Basketball

Ballistic missiles can be destroyed before firing or at three points during missile flight. As a missile is launched from its firing platform, it begins a **boost phase.** This phase can last between 30 and 120 seconds and ends when the missile motor stops burning. Satellites can detect the high heat burn of the rocket motor. Although this is the ideal time for intercept, timely shooter notification is difficult during this short phase. A ballistic missile will next enter a **mid-course/ transit phase.** The missile will reach its highest altitude, as high as 60 to 120 kilometers above the surface. It may leave the atmosphere, usually considered at altitudes above 100 kilometers. The **mid-course** phase can last a few seconds or several minutes. For some short range missiles, flight time is so short that there may be no mid-course phase. As a tactical missile begins its downward trajectory to attack a firendly asset, it enters the **terminal phase**.

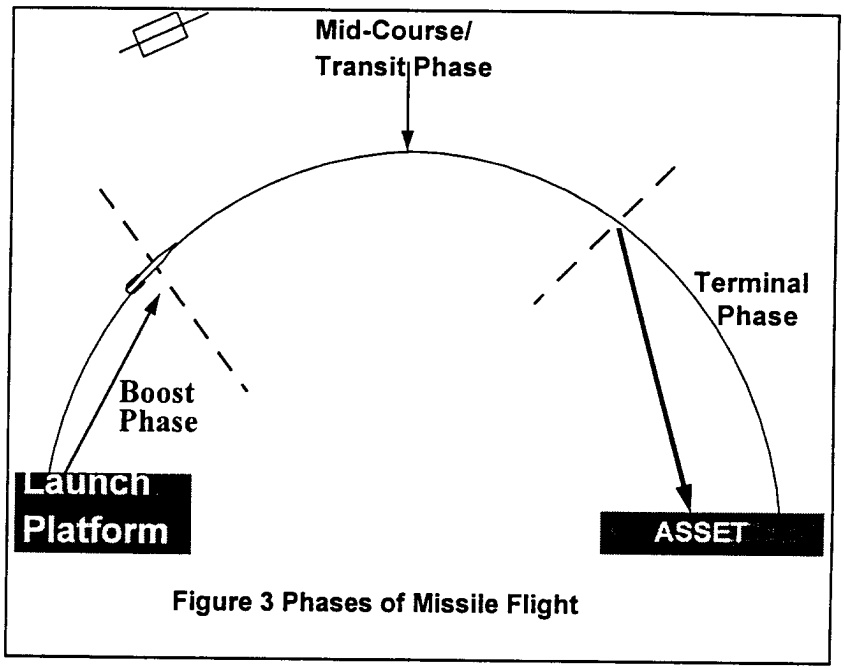

Figure 3 Phases of Missile Flight

TMD addresses missile threats before launch and during all three phases of missile flight. Defenses are designed to counter tactical missile threats by coordinating and integrating the four operational elements of TMD into cohesive and coherent combat operations. The four

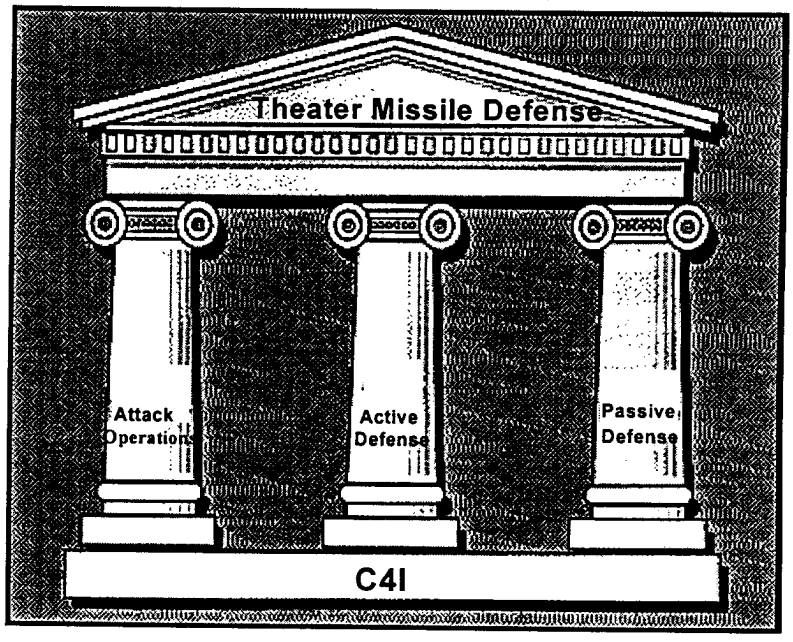

Figure 4 Pillars of Theater Missile Defense

elements of TMD are: attack operations, active defense, passive defense, and TMD command, control, communications, computers and intelligence (C4I).

Attack Operations. The preferred and most effective method of countering TM threats is to prevent the launch of tactical missiles by disrupting or destroying elements of the overall TM system before missile launch. These attacks include the destruction of launch platforms, reconnaissance, surveillance, and target acquisition platforms, command and control nodes, logistical infrastructure, and missile stocks. Systems used to support attack operations include attacks by fixed-wing aircraft such as the F-14 Tomcat and F-15 Eagle, rotary-winged aircraft, MLRS and ATACMS surface-to-surface missiles, Tomahawk missiles, neutralization through electronic warfare, as well as ground attacks by special operations forces.

Attack operations are dependent on predictive, quality intelligence to detect launch platforms and identify supporting infrastructure. During the Persian Gulf War, U.S. aircraft had great difficulty locating and destroying Iraq's mobile missile launchers. Despite the large number of aircraft dedicated to the mission (4,653 sorties) analysis done by the Department of Defense could not confirm that airpower destroyed even one launcher.[21] Of the 28 fixed launchers at the sites in western Iraq, only 14 had been destroyed. In southern Iraq, advancing Coalition troops found no abandoned Scuds, indicating the southern missile units were able to escape intact.[22]

Locating and identifying every mobile missile launcher in a potentially hostile country is beyond the technical capabilities of even the most advance reconnaissance sensors, particularly if the enemy is actively trying to hide them from view. Good sensor systems are still very scarce. 100 percent detection are necessary if nuclear or chemical warheads are available to the enemy. The damaging political impact of even a single chemical or nuclear attack on allied forces or friendly territory cannot be over estimated. It may force western political leaders to authorize retaliatory action using our own nuclear weapons.[23]

The gradual attrition of launchers over a period of time can have a significant effect on the number of missiles fired in a given day. This attrition would decrease the an enemy's ability to mass a missile attacks and improve the efficacy of TMD active defense forces.

The US capability to detect, track, and destroy mobile missile launchers has continued to improve. Joint Project Optic Cobra, conducted in conjunction with Exercise Roving Sands `95, maintained that shortcomings still exist in the ability to process and fuse available information and pass critical information to a weapon system. Sensor to shooter time-lines were insufficient to locate and destroy TM launchers.[24]

Active Defense. Active defense actions focus on the destruction of tactical missiles after launch and the destruction of airborne launch platforms. Politically, the deployment of Patriot batteries to Israel kept Israel from intervening in the war, providing a visible sign of US resolve to protect Israel. However, identified deficiencies and concerns meant that further improvements in TMD active defense were needed.

Since 1991, a considerable research and development effort has gone into weapon systems that can destroy missiles in flight. This destruction can be accomplished during any of the three phases of missile flight.

The active defense arena is divided into upper tier and lower tiers. These are defined by the altitude at which the intercept takes place and is a function of the speed of the interceptor and the missile. Normally, a lower tier engagement will occur during the terminal phase. and near established point defenses protecting a specific high value asset like a port or an airfield. An upper tier engagement will occur during the mid-course phase and would be able to protect areas a few hundred kilometers across because they would intercept missiles at greater ranges, high in the atmosphere. Together, the two tiers provide a layered defense that increases the effectiveness in areas that are protected.[25] However, at the present time an improved Patriot system

provides the only existing point defense capability in the US TMD arsenal. No upper tier system is presently available.

The Ballistic Missile Defense Office is developing a boost phase defense that would intercept missiles during the boost phase when the motor is still burning. The challenge is to get the interceptor situated where it needs to be when the location of the enemy's mobile missile launchers and launch time are not known. This aspect suffers from some of the same drawbacks as attack operations.

Each of the Services is developing active defense systems to intercept incoming missiles for both upper and lower tier areas. Each has a distinct view and approach to active defense, which carries certain advantages and disadvantages. These will be discussed in detail in the next section.

Passive Defense. There are two types of passive defenses: Operational measures and technical measures. Operational measures seek to minimize the effect that any single missile warhead can have. Forces can be dispersed, troops can use mobility and camouflage to reduce detection and targeting. Rear area forces and civilian populations can seek shelter, as they did in Riyadh and Tel Aviv in the Gulf War.[26]

Technical measures focus on early warning systems to notify troop formations and civilian populations of expected attacks, as well as protection against the effects of weapons of mass destruction. During Operations Desert Storm, military leaders used existing civilian defense warning systems (sirens) to notify the population of impending missile attack. Military units were notified by the cascade system, using organic radios through the chain of command.

Passive defense is one of the areas in TMD that is under addressed. In developed areas, where existing civil defense systems may exist, warning notification systems can be used to warn civilian populations. There is not standard approach for this notification. In developing countries, missile warning systems would have to be imported and procedures established. There is no standard joint signal, message or

notification medium to alert civilian populations of impending missile attack. In the time sensitive situations deployment of TMD forces are expected, there may be no time available to establish and implement a notification system. Similarly, the cascade system proved ineffective during the Persian Gulf War. There still is no effective method of notifying US, allied and coalition forces that a missile attack is imminent.

Even when passive defense measures are in place and protective cover is available, this lack of procedures means that US TMD forces and authorities will be unable to notify US, allied, and coalition forces and civilian populations that an attacking missile is approaching. Unnecessary deaths and injuries may be caused by this under addressed deficiency.

Command, Control, Communications, Computers and Intelligence.

Command, Control, Communications, Computers and Intelligence (C4I) systems link passive defense, active defense, and attack operations to provide a timely assessment of the threat, rapid dissemination of tactical warning, targeting data, mission assignment, and post strike assessments. C4I systems must provide rapid communications among intelligence assets, the fusion and decision making facilities, and warning systems.[27]

Space assets are critical to passive defense, active defense, and attack operations because they provide launch warning, launch point prediction, threat type determination, impact point prediction, weapons system cueing, communications and related intelligence.[28]

During the Persian Gulf War, TMD space operations were limited. The Defense Support Program (DSP) satellites were first launched in the early 1970's and use infrared sensors to detect heat from missile and booster plumes against the Earth's background. During Operation Desert Storm, DSP detected the launch of Iraqi Scud missiles and provided initial warning to civilian and military officials.[29] As infrared signatures were detected, data was transmitted to Cheyenne Mountain in Colorado, where it was quickly assessed, then transmitted via voice satellite link to the CINC's

Headquarters in Riyadh Saudi Arabia. Simultaneously, it was broadcast to Patriot units and selected headquarters in Saudi Arabia and Israel. This wide band broadcast was the first indicated that a launch had occurred, then refined the prediction, indicating whether the missile was headed toward Saudi Arabia or Israel. The time of missile flight from Iraqi launch sites to projected impact points ranged from four to eight minutes. Engagement orders were sent directly from Cheyenne Mountain to Patriot firing units. Missile launch to missile alert often took 2 1/2 to 3 minutes. This greatly reduced the time available for notifying affected civilians and military forces (passive defense), engagement of incoming missiles (active defense) or cueing fighters poised to strike. Clearly, a better C4I system was needed.

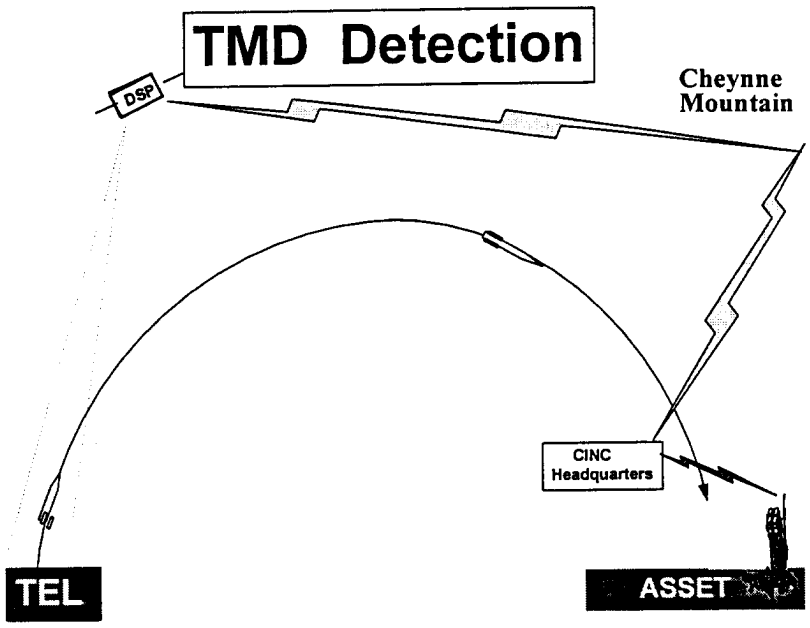

Figure 5 Desert Storm Early Warning

Since 1991, several improvements have been developed are expected to be fielded in the near future. The Joint Tactical Ground Station (JTAGS) is a new satellite receiver that allows direct downlink of missile and other warning data into the theater thus reducing information delay. Within 2 minutes of missile launch, tactical parameters, to include estimated impact area, are available to support tactical missile defense operations. USSPACECOM executes its control of JTAGS through the Army Space Command (ARSPACE).[30]

The ALARM satellite (Alert, Locate, Report Missiles), an improved DSP satelite was deployed in 1995. Tracking data from ALARM will help terminal phase defenses, like Patriot, focus its radar on a smaller portion of the sky, thereby extending the range of their radars and increasing somewhat the size of the area defended. ALARM will

also help other sensor systems locate and track empty missile launchers so that they can be destroyed.[31] The Space Based Infrared System (SBIRS), now in development, will replace DSP for the 21st Century. SBIRS enables U.S. and allied forces to detect theater ballistic missiles, sooner and at lower altitudes, enabling terminal phase systems to destroy them at longer ranges. As a result, the warfighter possesses an even greater ability to neutralize the theater ballistic missile threat. With SBIRS, space-based cueing will be available for direct downlink to a variety of offensive systems that can then destroy transport erector launchers immediately after launch detection. Space-based sensor systems for TMD are evolving well and aggressively being pursued by USSPACECOM.

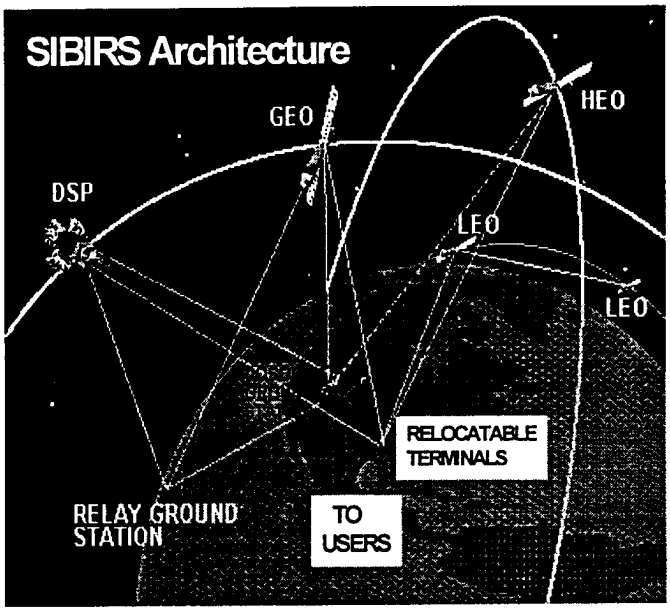

Figure 6 SIBIRS Constellation

During the Persian Gulf War, TMD command, control, and fire distribution was simple. Alert notification came from Cheyenne Mountain disseminated over the CINC's communication net. Attack operations information was sent through the JFACC. Since there was only one active defense system (Patriot), fire distribution was regulated through the internal Army (Patriot) system.

The Command and Control portion of TMD C4I is under addressed. As we look to field multiple systems for active defense in the coming years and integrated systems for attack operations using ground and air based platforms, each Service is addressing TMD issues using their own focus. These different foci are discussed in the next section.

Service Approaches to Theater Ballistic Defense

Each of the Services has taken a different approach to developing weapons systems to address the TMD threat. Each developing system adds depth and complexity to the theater missile battle. Service approaches will be examined as to how they address the four pillars of TMD: Passive defense, active defense, attack operations, and C4I.

Army Approach. The US Army sees the TMD battle as a distinct mission area with its own target set and command relationships. The combination of the theater high-altitude area defense (THAAD) and Patriot systems assembled in enclaves constitutes the Army's active defense against TBMs. To accomplish the TMD mission, active defense forces must protect key military assets and forces during deployment, entry, operations, and postconflict operations. In addition, the protection of selected geopolitical assets stabilizes the theater, prevents threat intimidation of allies or coalition members, and may provide for a measure of deterrence by demonstrating national resolve. The visible presence of ground-based TMD forces is also a visible sign to civilian populations of US intent to defend their homes.

Army planners believe that troops are prime targets for missile attacks and that the Land Component Commander should play a major role in TMD planning and execution. Toward that end, US Army officials have floated the idea of a "missile defense integrator," who would be assigned by the JFC to oversee the TMD tasks that the US Air Force believes should be JFACC prerogatives.[32] Thus, the Army approach places heavy emphasis on force protection and an enclave approach to defending critical assets.

Active Defense. The Army enclave approach to missile defense uses assets that are prioritized for defense while unneeded areas of sea or desert are left undefended.

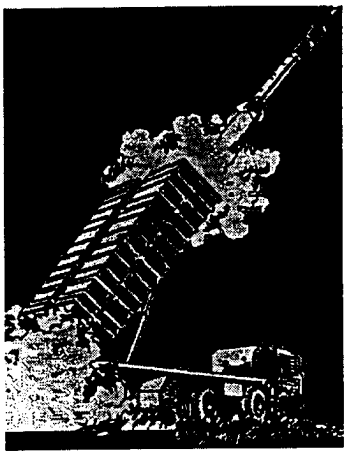

Figure 7 Patriot Missile Launcher

During the Gulf War, the PATRIOT air defense system made its now-famous battlefield debut against tactical ballistic missiles. Since 1991, the increasing threat from ballistic missiles spurred PATRIOT through a succession of improvements and modifications to refocus its mission on missile defense. Immediately following the war, the Quick Response Program (QRP) extended the engagement range. Today, the effort to improve the PATRIOT system and its ballistic missile defense capabilities continues as the latest version, called the PATRIOT Advanced Capability-3 (PAC-3), nears completion. With improved radar performance, extended range, and the new hit-to-kill missile interceptor to target the missile warhead, the PAC-3 enhancement will extend capabiities to more than 300% what Saddam Hussein faced.

The Theater High Altitude Area Defense (THAAD) is the most critical element of the core TMD program. THAAD is primarily an upper tier system that represents the first TMD system which has been designed to counter the existing [and projected] theater ballistic missile threats. The THAAD system is designed with much more powerful radars and much longer range hit-to-kill interceptor missiles that will enable the defenses to take two shots at an attacking ballistic missile. The defenses can take their first shot with THAAD missiles at very long range, probably outside the atmosphere (exoatmospheric),

look with their radar to see if the attacking missile has been destroyed and, if it has not, take a second shot with a THAAD missile inside the atmosphere (endoatmospheric)[33] or with terminal defense systems, if necessary.

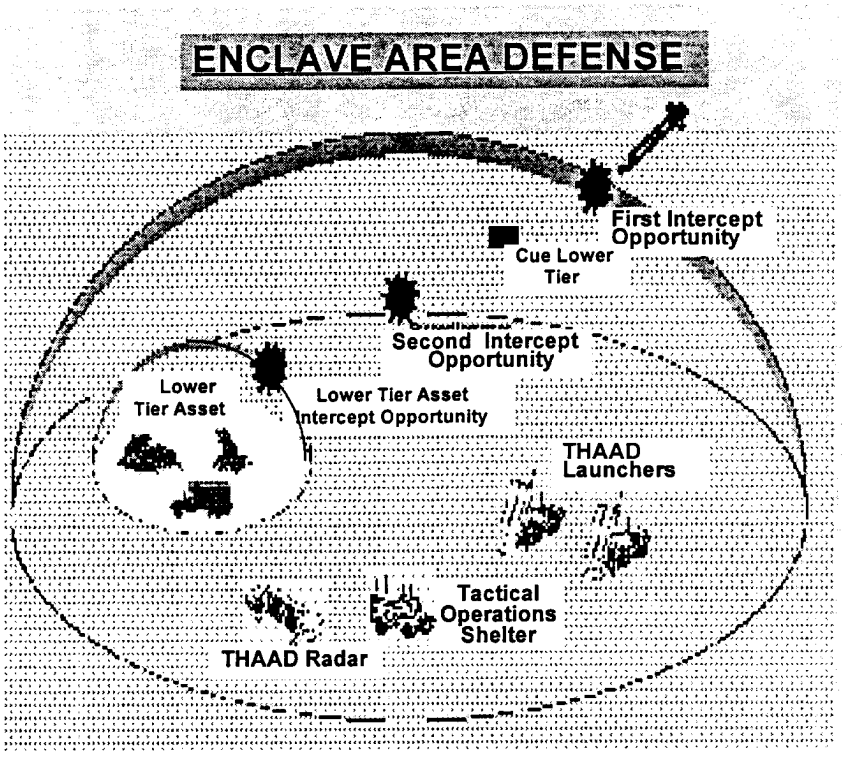

Figure 8 THAAD/Patriot Enclave

Advantages

- Patriot capabilities exist in the current force and are combat proven.
- Patriot (PAC-3) upgrades are currently being applied to the field.
- Patriot point defenses can move with maneuver forces as the battle progresses inland.
- THAAD upper tier UOES until was fielded in 1996, first unit capability is expected by 2004.
- Patriot and THAAD missile reload can be accomplished in limited time (minutes), concurrently with TMD operations.
- Patriot capabilities focus defenses on defended assets and do not `waste' coverage over sea or desert.
- Patriot and THAAD utilize state-of the-art hit-to-kill technology.

Disadvantages

- Political implications of land-based forces may limit utility during pre-conflict crises.

- Patriot requires considerable airlift (C-5/C-17) or sealift.
- THAAD requires considerable airlift (C-141) or sealift.
- Patriot and THAAD units require sustainment support from outside organizations.
- Patriot and THAAD require secure airfield or seaport for debarkation.
- Patriot and THAAD provide no boost phase intercept capability.
- Patriot and THAAD provide single mission capabilities to the JFC.

Passive Defense. The Army relies on satellite early warning to supplement organic TMD radars. The Army has experimented with a 'beeper' method to notify troops of impending missile attack. The 'beeper' method uses standard electronic beepers and a local cellular grid network. This system demonstrated a limited potential.[34]

C4I. The Army manages C4I for active defense through existing C4I nodes. This allows for external communication and fire distribution between Patriot and THAAD units. The Army has also developed a Force Projection Tactical Operations Center to provide the Land Component Commander (LCC) a mechanism to control TMD. It integrates active defense assets (Patriot, THAAD), with attack operations assets (Apache helicopters and ATACMS), and experiments with passive warning for maneuvering forces. Although a valuable tools for the LCC, it does not integrate operations with other attack operations elements.

Air Force Approach

Passive Defense. The Air Force is the lead for missile attack early warning. Existing and developing satellite constellations will provide increasingly better missile launch detection and notification to theater missile defenses. Existing cascade notification systems are used for notification of troop formations and civilian populations of expected attacks. This process worked well in Riyadh, Dhahran and Tel Aviv, but was ineffective for troop notification. In mature theaters, like Korea, interface with existing civilian alert systems will probably be sufficient. No system exists for civilian

notification is less developed areas or for notificatoin of maneuvering forces, other than the slow cascade system..

Active Defense. The US Air Force views TMD as a natural extension of its air defense mission. Like aircraft, cruise and ballistic missiles are flying objects that require intense air coordination. Like maneuver units on the ground, mobile missile launchers are one among many time-critical ground targets against which reconnaissance and attack resources must be allocated.[35] The Air Force is developing weapon systems that augment and enlarge current capabilities.

The Air Force is pursuing the Airborne Laser (ABL) that is expected to be an airborne platform to be an air-refuelable, wide-body aircraft that can deploy worldwide and close with other early-arriving air assets. Once in theater, it will quickly establish an on-orbit combat air patrol to help protect the arrival of other U.S. and Coalition forces. The ABL will have an on-board, passive infrared sensor operating in a 360-degree sweep. It will be capable of autonomous detection, acquisition, and tracking of TBMs with no external cueing required. In addition, the ABL will incorporate a high energy, chemical laser in the multi-megawatt class. It will carry sufficient laser fuel for 30 to 40 engagements per 12- to 18-hour mission. [36]

If the technology develops as presently anticipated, the ABL could will provide a boost-phase theater ballistic missile intercept capability. By attacking theater ballistic missiles early in the boost or mid-course phase, the enemy faces the potential of having his own weapon fall back upon his territory. The Air Force is also developing kinetic energy, airborne interceptor would be carried on fighter aircraft for high altitude release against ballistic missiles.

Advantages

- Boost phase intercept offers greater defense than intercepts over friendly territory, especially when dealing with weapons of mass destruction.
- Reduces the need for notification of civilians and troop formations.
- ABL will be able to self deploy and will not rely on airlift or sealift.

Disadvantages

- ABL relies on technology that is not completely proven and may be less effective when dealing with greater distances and differing weather masses.
- Extensive reliance on alert cueing, that has proven most difficult in the boost phase.
- A slow spin on the attacking missile could greatly reduce the laser intensity needed to destroy it.
- Getting ABL within range to intercept missiles in the boost phase is difficult, due to the extremely short flight time of the boost phase and the uncertainty when the enemy will choose to launch.
- Ground support requirements have not been articulated and may require sophisticated equipment.
- ABL will be a high cost system and will require additional airborne protection.
- ABL and boost-phase intercept may not be available until well after 2010.

Attack Operations.

The Air Force continues to refine procedures to detect, cue, and attack missile launchers and their infrastructure. Although considerable progress has been made in identifying fixed sites and supporting infrastructure for mobile launchers, the location of mobile launchers after launch still remains a difficult task.

Command and Control

The Air Force, in partnership with BMDO and the Marine Corps, is developing a capability to decentralize attack operations against mobile TBMs. The Combat Integration Center (CIC) receives sensor data from space-based assets and joint radar systems, then employs JTIDS to flash targeting and warning information across the

entire theater. Meanwhile, it employs a number of decision aids to recommend offensive and defensive actions against the specific TBM threat. In recent exercises, CIC operators were able to process sensor inputs and task attack assets within one to two minutes.

Advantages

- Reduces cueing time for attack operations against mobile missile launchers.
- Provides a mechanism for consolidating attack operation efforts.

Disadvantages

- US Navy and US Army have not integrated active defense and attack operations assets into the CIC cycle,
- Lacks a common vocabulary, message format, symbology, and reference points
- Passive defense actions are not integrated into CIC operations.

Navy Approach.

Active Defense. The US Navy approaches TMD using a sea-based Wide Area Defense focused on the active defense phase. Using existing AEGIS cruiser and destroyer platforms, naval ships can be positioned early off the coast of a potential adversary to deter as well as defend against tactical missile threats, and therefore buy time for negotiation of regional differences.[37] Thus, a TMD force can be in place to provide Navy area defense before hostilities erupt or before land-based defenses can be transported to the theater.[38] A TMD equipped ship could deploy with both lower tier and upper tier capabilities.

The Navy's lower tier system can protect point targets near the coast. This ability makes it a natural choice to protect ports, key assets of coastal cities, and Marine amphibious forces. A lower tier capability, similar to the Patriot capability, requires an enhancement to the existing Aegis SPY-1 radar and a new modification to the standard missile (SM-2 Block IVa). Specific coverage depends on the circumstances and the location of the ship off-shore.[39] The Navy plans to upgrade the Aegis computer

program in 1998 and deliver the first block IVa missile in FY 2000. The first TMD equipped Aegis cruiser (lower tier) is expected by FY 2002.[40]

The Navy's upper tier system, termed the Wide Area Defense is designed to attain a very fast, long-range intercept against threat missiles during the boost phase of flight. This allows the system to defend a larger area than may be possible with a terminal defense systems. This system uses a kill vehicle designed for exoatmospheric intercepts and thus it cannot rely on the atmosphere for discrimination[41] Without atmospheric discrimination, the presence of other objects near the threat missile could potentially degrade upper tier performance. The system will also be capable of engaging attacking missiles during the mid-course phases. Ships might be deployed between the missile and the target. For example, if the Aegis ship located in the Mediterranean Sea, were defending Europe against missile fired from North Africa, sea-based TMD systems might have a significantly greater range and engagement opportunity than land-based systems.[42]

Advantages.

- Naval forces can be the first forces on the scene of a crisis and may provide a more politically acceptable actions during pre-conflict crises.
- Sea-based TMD systems will be integrated into existing Aegis platforms.
- Aegis platforms bring additional anti-air and TOMAHAWK capabilities.
- Sea-based TMD forces are self deploying and do not rely on airlift or sealift, nor do they rely on availability of secure airfields or ports.
- Aegis ships equipped with upper tier capabilities can position close to suspected littoral TBM launch points and may be able to destroy enemy missiles in the boost phase.
- Sea-based TMD systems are especially well suited to protect amphibious forces moving ashore from the sea.[43]

Disadvantages

- Sea-based TMD systems will 'waste' a portion of their coverage over open sea. The enemy's use of cruise missiles or mines could increase this

'waste' area and reduce lower tier coverage.[44] In certain littoral areas, tides may limit optimizing ship locations.

- Some Aegis platform capabilities may be reduced as magazines are optimized for TMD missions.
- Aegis missile reload requires considerable time (days), and cannot be accomplished concurrently with TMD operations.
- Aegis TMD requirements may limit or eliminate traditional Aegis functions performed for the carrier battlegroup. Construction of additional Aegis platforms may be required.
- The existing SPY-1 Aegis radar was designed for air defense rather than theater ballistic missile defense.[45] Significant upgrades are required.
- Aegis platforms are vulnerable to anti-ship missiles and other weapons Additional Aegis weapons to provide these defenses may reduce TMD capabilities. Additional ships to screen TMD operations may be required.
- Sea-based TMD systems may have limited effect on tactical missiles fired at relatively short ranges (350 Km and below).
- Sea-based TMD forces will not be available until 2002 (lower tier) and 2010 (upper tier).

Passive Defense

Navy early warning for missile attacks is established through existing cascade notification systems. No other capability exists to notify troop formations ashore and civilian populations of expected attacks.

Attack Operations

The Navy has largely ceded attack operations to the Air Force and the Army. The Air Force-Army debate over counterforce boils down to the Air Force's one-size-fits-all doctrinal mentality versus the Army's call for a dedicated approach to finding and attacking mobile missiles. Parochial interests color both approaches.[46] Naval aircraft

and strike missile capabilities are available to the Joint Force Commander as resources for strikes on missile launchers and infrastructure. Although training for these conventional missions is conducted, no new systems or procedures are not being developed for this mission area. The Navy could bolster its active defenses by pursuing a mobile target-seeking capability for its Tomahawk land-attack cruise missiles and/or developing a sea-launched variant of the Army's ATACMS ballistic missile system, but to date these counterforce options have received limited attention.[47]

Command and Control

The Navy is pursuing a Cooperative Engagement Capability (CEC) that offers great possibilities for TDM active defenses. It provides three separate, but interdependent functions: composite tracking, precision cueing, and coordinated engagements. A consolidated track pulls radar data from multiple sources, processes it into a single target picture, then returns the consolidated results to individual users.[48] Cooperative engagement allows a TMD weapon system to fire a defensive missile, guide it to enemy tactical missile, and destroy the attacking missile, using radar data from another CEC radar.[49] CEC has the ability to direct engagements, reducing the possibility of multiple engagements on a single attacking missile.

Advantages

- A single control mechanism for TMD active defense.
- Consolidates views of the battlefield that exceeds the capability of any single radar.
- Does not include mechanisms for passive defense warning.

Disadvantages

- Slaves radars to CEC system. Does not allow independent prioritization of locations and platforms.
- Lacks a common vocabulary, message format, symbology, and reference points.[50]

MARINE CORPS APPROACH

Active Defense

The object of Marine Hawk TDM capability is top provide point defense against short range missiles such as FROGs, SS-21s, and short-range Scuds. Hawk will not be able to engage longer range missiles, such as Scuds that are fired from distances of 500 kilometers or more.[51]

Theater Missile Defense - An Assessment

The **Threat** continues to expand. The number of nations possessing tactical missiles and the ranges and accuracy of missiles available and in development continues to grow.

Attack Operations is the preferred, but most difficult element of TMD. During the Persian Gulf War, ground attacks by Special Operation forces proved most productive. Aerial attack operations proved frustratingly poor. Locating mobile launchers is still a difficult, unproductive task. Continued development is required.

Tremendous funding has gone into **Active Defense** development. After six years of effort, only point defenses are available to the operational commander. Defending geopolitical assets and maneuvering forces, the Patriot system, with continuing system upgrades, remains the only capability against attacking missiles. Aegis systems provide adequate defenses against missiles targeted against the fleet.

The near-term future promises expanded point defenses, as Aegis joins Patriot with capabilities to protect ports and littoral airfields and forces operating in littoral areas. There will be no new defenses against longer range missiles, ranges greater than 950 kilometers, until the middle of the next decade, when THAAD enters into the force in limited numbers. Navy theater-wide systems may be available later in the decade. Systems like Airborne Laser and other high technology based systems remain on the distant horizon.

Passive Defense is dependent on early warning for both TMD weapon systems and notification of vulnerable military forces and civilian populations. The deployment of the ALERT satellite is a step in the right direction, but the problem will wait for resolution until SIBIRS is deployed in the middle of the next decade. Communications is available to disseminate early warning to TDM weapons systems, but there is insufficient procedures for notifying vulnerable military and civilian populations. There no standard approach for notification. In developing countries, missile warning systems would have to be imported and procedures established. There is no standard joint signal, message, or notification medium to alert civilian populations of impending missile attack. In the time sensitive situations deployment of TMD forces are expected, there may be no time available to establish and implement a notification system. Notification of maneuvering forces and civilian authorities remains an under addressed area.

The deployment of early warning satellites and JTAGS is addressing the current and near term communications portion of the **C4I** problem. Against the realistic threat of as many as 18 missiles being launched near-simultaneously, the fire control does not exist to determine which asset is directed against which missile, at what stage of the engagement. We could end up with multiple missiles and the ABL engaging the same set of attacking missiles, while others fly to their target. An expensive concern is that for each attacking missile, ABL, THAAD, Navy upper tier, Patriot, and Navy lower tier would all launch missiles. At almost $1 million for each missile, this would be very expensive. Fire distribution remains a critical under addressed area.

TMD has made great strides since the end of Operation Desert Storm. Improvements have been fielded for the Patriot system and other approaches and technologies are being rapidly developed, especialy for active defense capabilities. The areas of passive defense and C4I remain under addressed.

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ANNEX A
UNANSWERED QUESTIONS

The following questions are open issues to be addressed as TMD develops.

1. C4I

a. What is the appropriate command relationship for TMD forces, given multi-Service TMD forces available for active defense and attack operations?

b. Who should direct the TMD battle for the Joint Force Commander?

c. What automated tools are needed to cue TMD weapons systems to ensure greater than 90% lethality and avoid duplicative engagements?

d. What technological and procedural adjustments are needed to integrate TMD sea, air, and land forces?

e. How can the Navy Cooperative Engagement Capability be developed to provide a TMD fire distribution system for lower tier defense?

f. What standardization is required for vocabulary, message formats, symbology and reference points to integrate multiple Service approaches toward TMD.

g. Are the inadequacies of the Alert, Locate, Report Missiles (ALARM) satellite for early warning sufficient to warrant the early deployment of Space Based Infrared System (SIBIRS), or Brilliant Eyes type system?

h. What procedures or technologies decrease the sensor to shooter time? How can these be improved?

2. Passive Defense

a. What joint procedures and technologies are appropriate for notifying civilian authorities of impending missile attack? In developed countries? In less developed countries?

b. What joint procedures and technologies are appropriate for notifying maneuvering troop units and military installations?

3. **Active Defense**

   a. How can Navy lower tier TMD systems be integrated into the Army enclave concept?

   b.. How can redundant engagements be facilitated given THAAD, Navy upper tier, and airborne laser capabilities against similar attacking missiles?

   c. How can the lift requirement for surface-based TMD systems be reduced?

   d. What are the protection requirements for the airborne laser, given its high cost and considerable value to the nation?

   e. How can Special Operations Forces be maximized for target detection and cueing?

4. Attack Operations

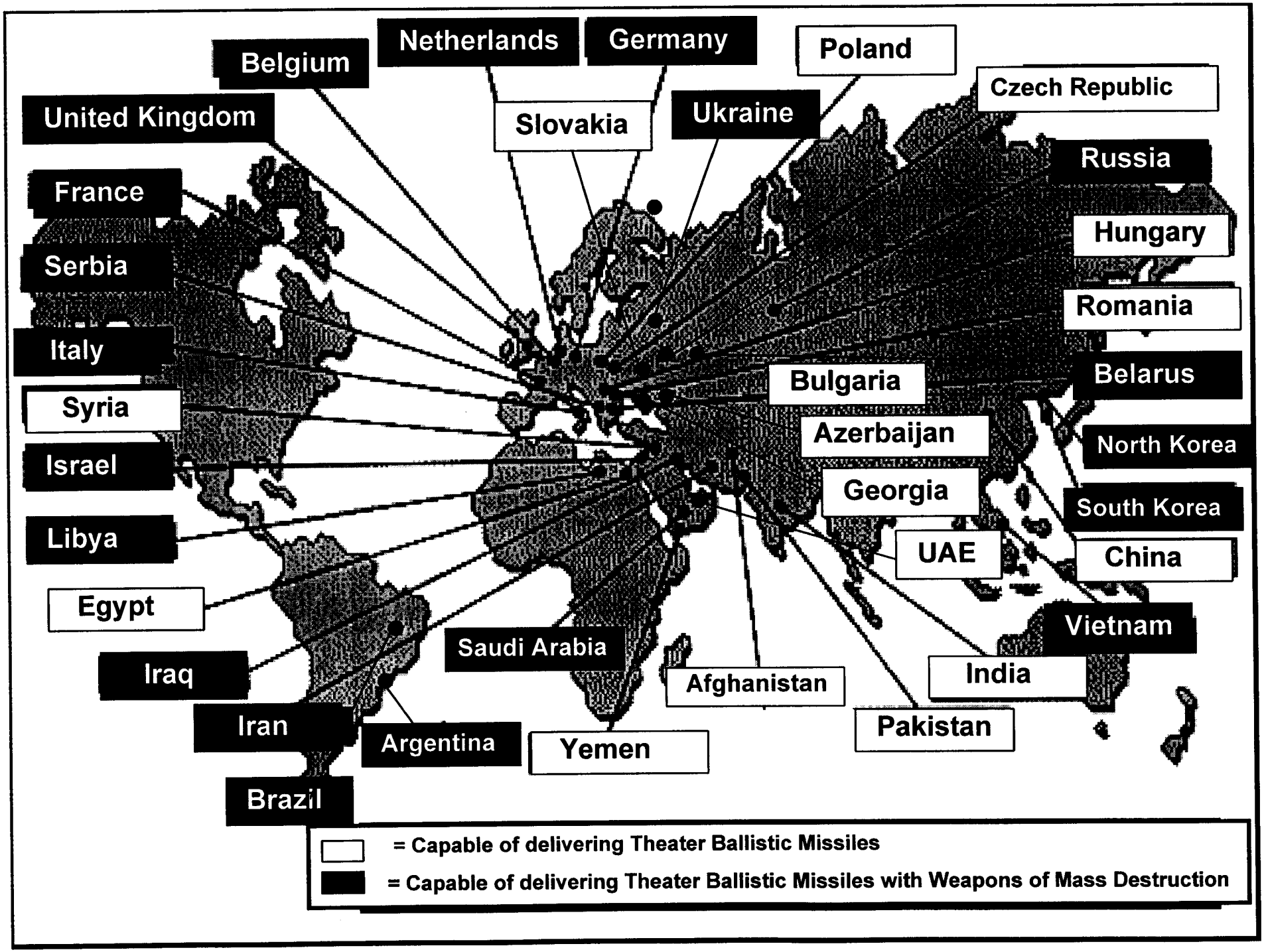
   a. What procedures can be developed to determine the appropriate attack mechanism for destroying mobile, fixed missile launchers and supporting infrastructure, given airborne and surfaced based platforms of multiple Services?

   b. How can the Air Force Combat Integration Center (CIC) be expanded to include Navy and Army attack operations?

ANNEX B
BRIEFING SLIDES

This annex provides additional slides to facilitate briefing the TMD concepts to the uninitiated.

1. The Growing Threat
2. The Pillars of Theater Missile Defense
3. Pillars of Theater Missile Defense (explained)
4. Service Approaches to TMD
5. TMD Detection during Desert Storm
6. Current TMD detection Mechanisms.
7. Army Enclave Area Defense
8. Active Defense Weapon Systems
9. SIBIRS Architecture


Belgium
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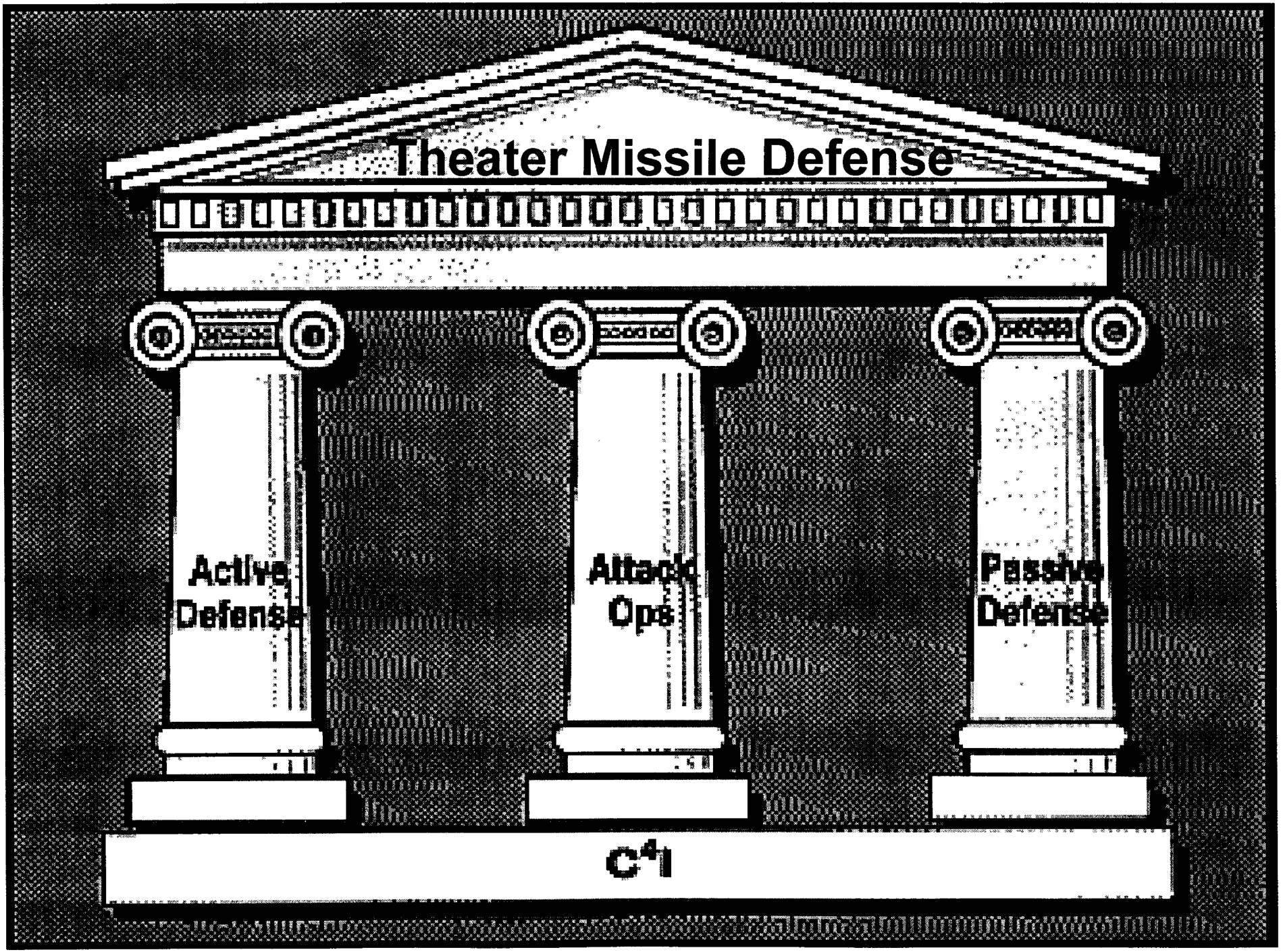
Poland
Czech Republic
United Kingdom
Slovakia
Ukraine
Russia
France
Hungary
Serbia
Romania
Italy
Belarus
Bulgaria
Syria
Azerbaijan
North Korea
Israel
Georgia
South Korea
Libya
UAE
China
Egypt
Vietnam
Saudi Arabia
Iraq
India
Afghanistan
Iran
Pakistan
Argentina
Yemen
Brazil
= Capable of delivering Theater Ballistic Missiles
= Capable of delivering Theater Ballistic Missiles with Weapons of Mass Destruction


Theater Missile Defense
Active Defense
Attack Ops
Passive Defense
C4I

Pillars of TMD

Attack Operations

Prevent the launch of Tactical Missiles by destroying missile launchers and Infrastructure

Active Defense

Destruction of Tactical Missiles after launch has occurred. Divided into Upper and Lower Tiers.

Passive Defense

Operational measures to reduce the effectiveness of Tactical Missiles. Technical measures to notify manuevering forces and civilian authorities of impending attack. Efforts to nullify the effects of WMD.

C4I

Links other pillars to provide a timely assessment of the threat, rapid dessemination of tactical warning, targeting data, mission assignment, and post strike assessments.

Service Approaches to TMD

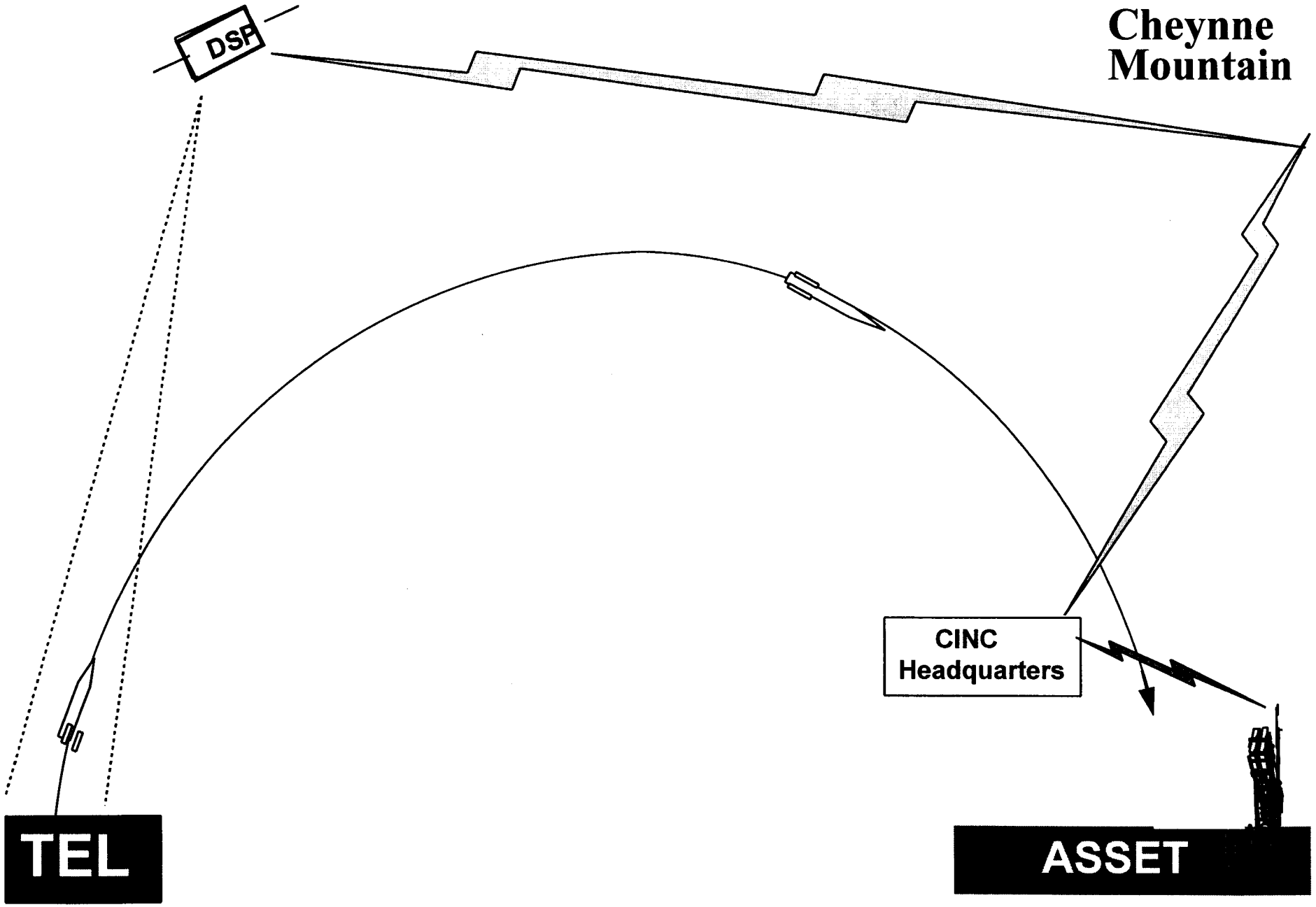
Army TMD is a distinct mission area with its own target set and command relationshhips. Defense systems are combined into enclaves of upper and lower tier.

Navy TMD focus on deterrrence and active defense. Naval ships can position off the coast to provide area defense before hostilitiys erupt. Using existing Aegis platforms, the Navy provides lower tier and upper tier capabilities.

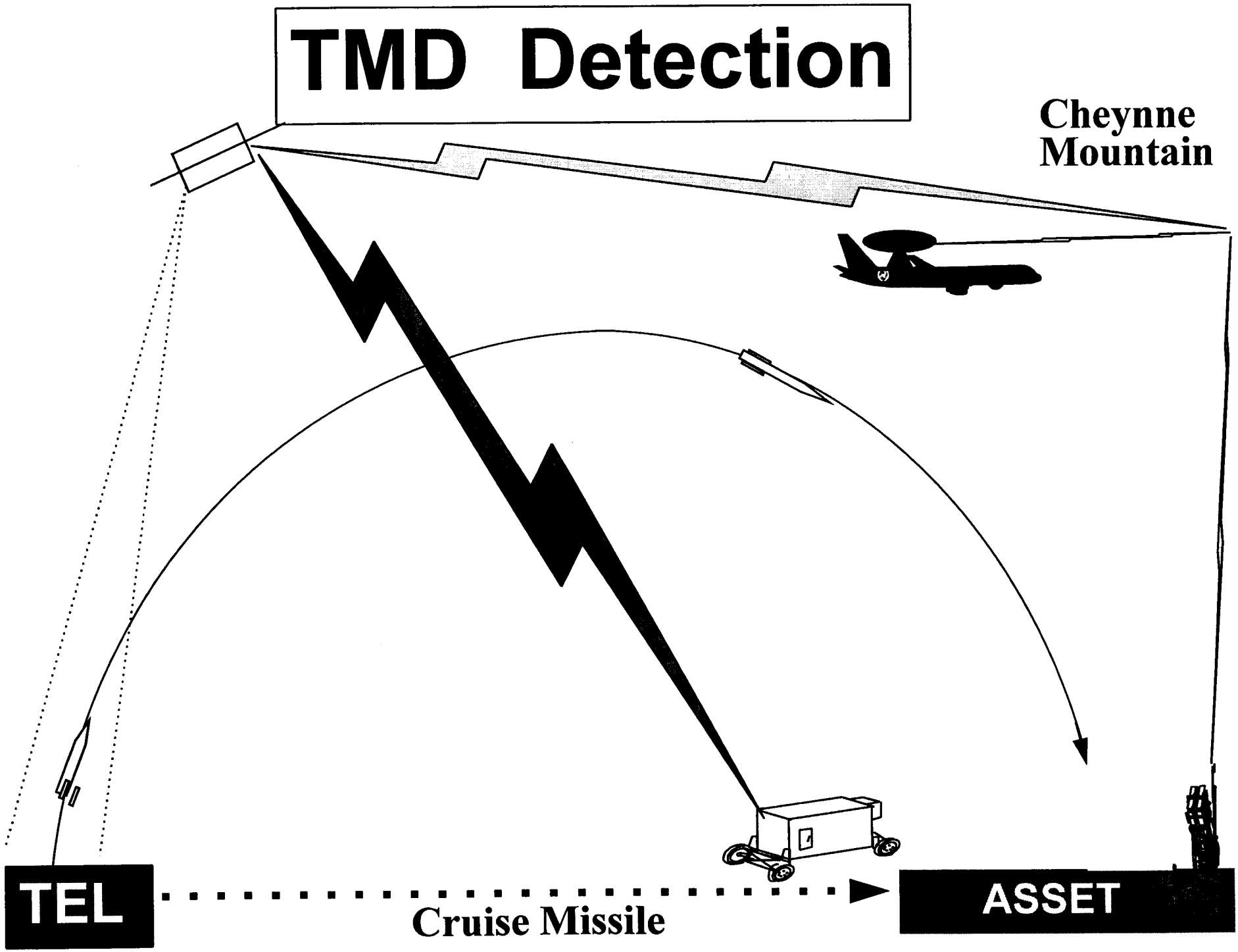
Air Force TMD focus is on attack operations. As a natural extension of the air defense mission, mobile launchers are one among many time-critical targets against which reconnaissance and attack resources must be allocated.

USMC TMD focus is to provide point defenses against short range misssiles.

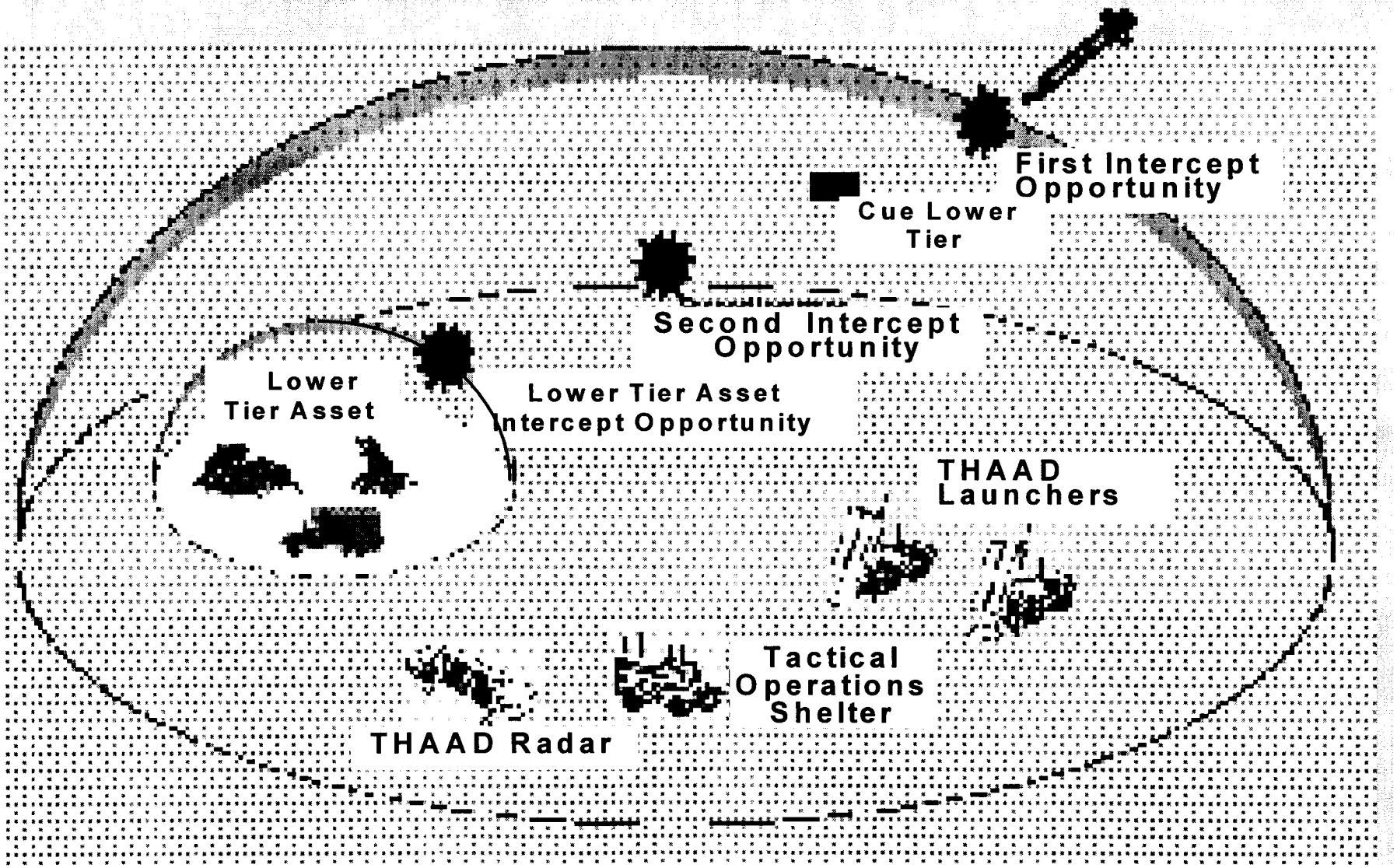
TMD Detection during Desert Storm



TMD Detection

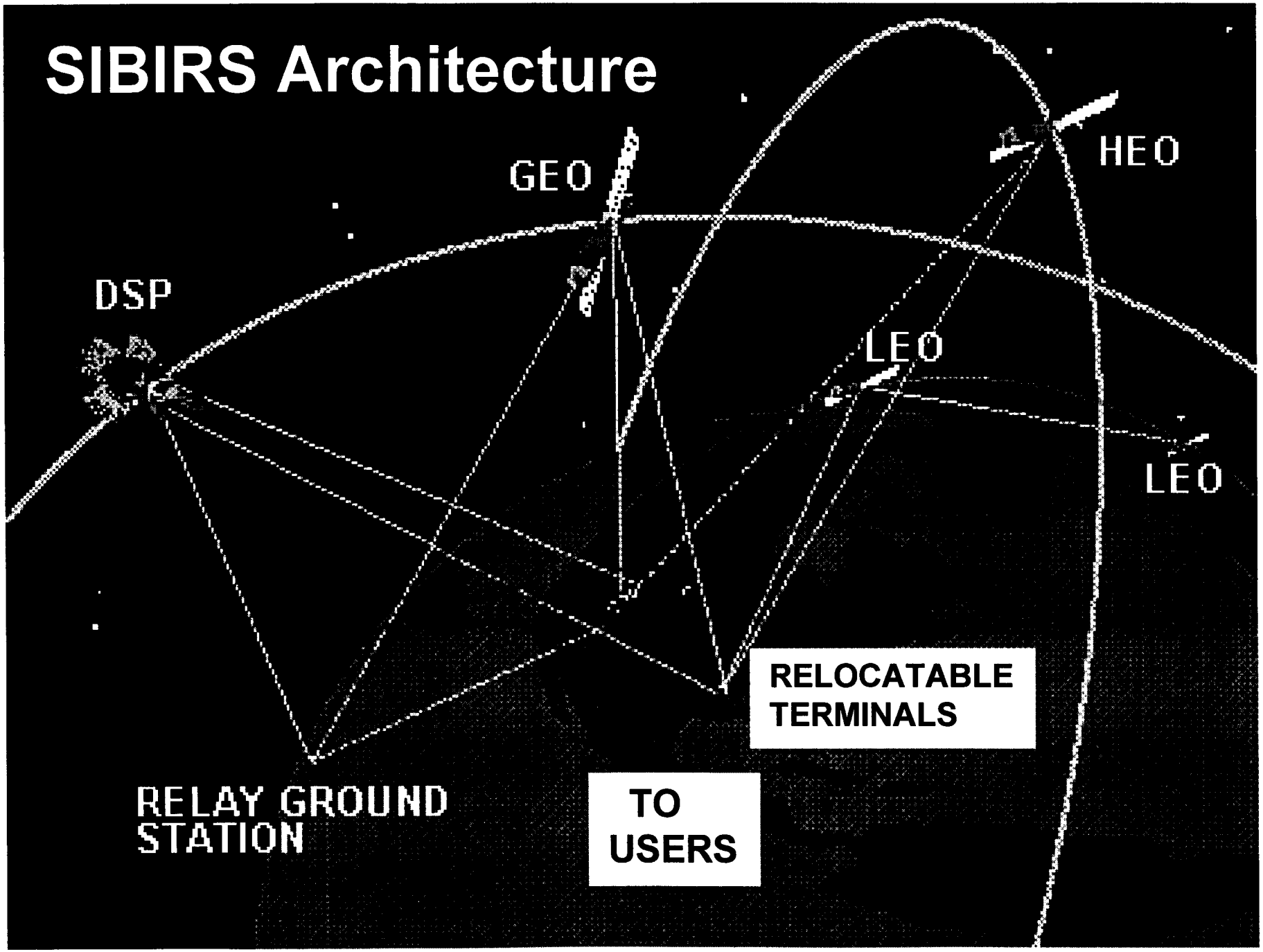


ENCLAVE AREA DEFENSE



Active Defense Weapon Systems

	1999	2005	2015+
LAND	Patriot (PAC-3) USMC Hawk	Patriot (PAC-3) THAAD	Patriot (PAC-3) THAAD MEADS
SEA		Aegis (lower tier)	Aegis (upper tier) (lower tier)
AIR			Airborne laser Boost interceptor?


SIBIRS Architecture
GEO
HEO
DSP
LEO
LEO
RELOCATABLE TERMINALS
RELAY GROUND STATION
TO USERS